# Spatial Arbitrage and Market Integration: Some Results from Spatial Equilibrium Model for Lamb Market in Southern Kazakhstan

Mimako Kobayashi

Ph.D. Student and Research Assistant
Dept. of Agricultural and Resource Economics
University of California, Davis

**Draft: Please Do Not Cite**

## Introduction

Emergence and development of agricultural markets is essential to reconstructing and restructuring of the agricultural sector in transition economies. In the era of a planned economy, agricultural marketing for both inputs and outputs was controlled by the state. In the course of transition to a market economy, a market mechanism was introduced but such controlled marketing did not disappear right away. Blanchard and Kremer (1997) argue that such disorganization of existing production and delivery links is one of the largest causes of decreased output in transition economies.

In the agricultural sector, another important structural change that has occurred is the decollectivization of state farm enterprises into individual farms. While surviving farm enterprises, either state-owned or privatized, may seek to reestablish the channels for input delivery and output marketing, new individual farmers are on their own.

A broader question that follows is how well agricultural markets function in transition economies. One aspect of this question is: How well integrated are geographically disperse markets? Studies on market integration for transition economies exist but are still scarce. Examples are Rozelle et al. (1997) and Wan (1997) for China and Berkowitz et al. (1996) for Russia.

In this paper, we will examine the efficiency of spatial arbitrage and the extent of market integration for the livestock sector in Kazakhstan. In this former Soviet Union republic, the level of spatial integration of livestock markets has many policy implications. First, while this sector was heavily protected during the Soviet period, it has not drawn any attention since independence. Without marketing orders, support prices, subsidies, or any kind of policy measures, the only platform on which farmers in this sector perform is the marketplace.

Second, whereas most of the livestock was held by state and collective farms during the Soviet era, these animals were distributed to individual workers or simply liquidated after the dissolution of such large farms, making individuals the principal holders of livestock. Although organized traders are appearing, individual farmers are largely responsible for marketing their animals to the consumers and retailers.

Third, since independence, the transport system in Kazakhstan has been deteriorating, due to the lack of maintenance. According to a World Bank report, 1500 km (about 9%) of the total road network disappears each year and about 30% of the railroad network needs major repairs.[1]

This paper is organized as follows. In the next section, we test for spatial integration of various livestock markets in Southern Kazakhstan and find that markets for small animals in this region are connected. Section III describes the spatial equilibrium model constructed for the lamb market in this region. In section IV, we conduct several simulation exercises to explore the explanations for the

[1] World Bank (1996), pp. 3-5.

results found in section II. The final section concludes the paper and provides further research issues.

## Test for Spatial Integration of Livestock Markets

Several methods are employed in literature to test for market integration. One widely used method is to apply cointegration test, a time-series technique of econometrics, on price data series. This method tests for co-movement of prices from different places and searches for long-run relationships between them.[2] When prices of the same commodity from different places move together in the long run, the information of local surplus and deficit is considered to be well transmitted across space. Therefore, the market for that good is well integrated.

Another increasingly popular test focuses on spatial arbitrage. Arbitrage by suppliers works as follows. When a supplier at place A, selling his goods at a certain price, finds that other suppliers at place B are selling the same goods at a higher price, we can expect that he will move to place B and sell his goods there. The movement will stop when moving to place B is no longer profitable, i.e., the cost of moving (transport, information, etc.) exceeds the price differential. When this spatial arbitrage is not done efficiently, i.e., prices differ by more than the cost of moving between markets, the market is not spatially integrated. This second method estimates the probability of efficient arbitrage to test for spatial integration.[3]

Although we recognize the imperfections of the first method,[4] we rely on the first method in this paper because of data limitations. To conduct the second test, detailed information on both prices and trade flows (direction and volume) are necessary. However, we have only price data. Also, the second test is only applicable when there is a direct flow of goods between the places in consideration. As explained below, the nature of trade in Kazakhstan is not such. There are intermediate places that are involved in the regional trade, and data is not available for these places.

We use a data set provided by EU/TACIS (European Union, Technical Assistance to Confederation of Independent States) for prices of various livestock at three animal bazaars in Southern Kazakhstan. Animal bazaars are usually held once a week on the weekend, where people directly buy and sell various types of animals. While suppliers are mostly individual farmers, buyers include individual farmers, butchers, and restaurant owners. Organized traders have yet to be found.

Animal bazaars are held throughout the region. At each oblast (state) center, a large animal bazaar is found. Each rural raion (county) center has a smaller bazaar. Village-level animal bazaars are found but rare. The TACIS data cover bazaars at oblast centers for selected oblasts. Here we will look at oblast bazaars in Southern Kazakhstan for which the information is relatively well documented. These bazaars

[2] This is parallel to a correlation coefficient that measures co-movement of series in the short run.
[3] See Baulch (1997a) for example.
[4] Baulch (1997b) and McNew and Fackler (1997) show that the cointegration test does not detect spatial integration correctly.

are located in Almaty of Almaty Oblast, Taraz of Dzhambul Oblast, and Shimkent of Southern-Kazakhstan Oblast.

Figures 1-A and 1-B show the price movement of small and large animals in these markets from 6/16/1998 to 5/11/1999. A casual examination of these figures may suggest that the prices are by and large moving together for each type of animal. For some types (fat-tailed lambs and sheep and young cows), however, there are large price differences between the three markets.

Table 1 summarizes the results of statistical tests for spatial integration. Cointegration tests are conducted both pairwise (e.g., between Almaty and Taraz) and groupwise (i.e., three markets as a system). When we find cointegration, we list the estimated cointegrating equation (long run relationship) between the prices for those pairs and groups.[5] As a reference, we also calculate pairwise correlation coefficients between prices as reference.

For small animals, we find the highest correlation between the prices in Almaty and Shimkent. This suggests that the strongest short-run relationships in prices are found between of Almaty and Shimkent, which is counterintuitive because these two markets are the furthest apart. We always find a long-run relationship as well for the Almaty-Shimkent pair when the test is applicable. No cointegrating relationship is found for the Almaty-Taraz pair, and the result is mixed for the Taraz-Shimkent pair.

The puzzle seems to be emanating from the problem of pairwise techniques that ignore the complexity of nonlinear trade relationship of the system.[6] The groupwise cointegration test may mitigate this problem since in this way we search for a long-run relationships in all prices for the system. The results of groupwise tests for small animals suggest that the market for lamb is integrated. For thin-fleeced lambs, we find two cointegrating relations, which suggest the most explicit relationships between prices in the three markets. We cannot confirm market integration for adult sheep.

For large animals, the groupwise tests suggest cointegration for cows and young cattle of meat-milk type. However, the cointegrating equations have a trend term, T, in it, implying that the long-run relationship between the three price series changes over time. For example, the cointegrating equation for cows of meat-milk type suggests that the weighted sum of the three prices will decline over time. It is unlikely that such results suggest market integration.

It may be risky to conclude market integration for small animals based only on these results of cointegration tests, especially when we have only a small number of observations. Also, market integration is counterintuitive in this region because we do not observe direct trade flows of animals between Almaty, Taraz, and Shimkent. However, we cannot disregard these statistical results simply by following

[5] Cointegration tests are applicable only when the series are nonstationary. For some pairs and groups, we cannot apply the test because we find stationarity of series. Such pairs and groups are marked by n.a. (not applicable) in the table.

[6] Baulch (1997b).

our intuition. In the following sections, we will analyze the regional trade of lambs in detail to see how market integration is possible when trade occurs indirectly.

## Spatial Equilibrium Model for Lamb Market

To examine the trade flows and price movement in the lamb market in Southern Kazakhstan, in this section we adopt a spatial equilibrium approach. Spatial equilibrium models have two major aspects. One aspect comes from the term "spatial." First, rather than dealing with multiple markets at one place as general equilibrium models do, spatial equilibrium models usually consider one commodity at multiple locations.[7] Secondly, the closure rule in spatial equilibrium models implies that supply and demand must be equal in the region as a whole, but not necessarily at each location. Therefore, a deficit in one place implies an overall surplus in the rest of the region.[8]

Spatial equilibrium models are often used to find the optimal distribution of goods over space. These models are also used to simulate welfare impacts of various policy measures.[9] In this section, we describe our spatial equilibrium model for the lamb market in Southern Kazakhstan. This model is then subjected to policy simulations in the next section.

The spatial equilibrium model in this paper consists of eight market points in two oblasts in Southern Kazakhstan (Dzhambul Oblast and Southern-Kazakhstan Oblast).[10] Figure 2 shows the geographical relationship of the eight locations. Big black dots represent oblast markets, and other circles represent raion markets. The size of the circles represents different market sizes. Since we do not have information about all of the animal markets in the rural raions of this region, we treat the rest as an aggregate of all the other raion markets. These aggregated markets are represented by ovals.

Each market point has different characteristics in terms of supply, demand, and relationships with other markets. In Dzhambul Oblast, Taraz (T in Figure 2) is the oblast center. It has a large demand and a relatively small supply. Baizak Raion (B) is very close to Taraz (about 20 km) and people can easily use Taraz for market transactions. Therefore, no active market has developed in this raion. We treat this "market" as a supplier with zero demand. Karatau in Talas Raion (K) is located in such a way that the farmers there can supply in their local market, the oblast center (Taraz), and the demand center in another oblast (Shimkent). The cost of transport determines the net profit, which influences where people decide to sell their

---

[7] Some authors have also developed multi-commodity spatial equilibrium models. For example, see Martin (1981).

[8] The models can easily be open to outside the region by incorporating "import" from and "export" to the outside world.

[9] Examples of application of this approach to developing countries are Yao and Colman (1990) for Chinese grain sector and Mwanaumo et al. (1997) for maize in Zambia.

[10] The econometric tests of market integration in section II involved an additional oblast (Almaty Oblast). Here for simplicity we model only these two oblasts. The model is planned to extend to a three-oblast model in the future.

livestock. Zhanatas in Sarysu Raion (Z), on the other hand, is so far away from big markets that people buy and sell animals only at this local market.

In Southern-Kazakhstan Oblast, Shimkent (S) is the demand center. Since information about this oblast is extremely limited, we treat Uzunagach (U) in Zhambyl Raion, Almaty Oblast, as if it were in a raion in the Southern-Kazakhstan Oblast. Uzunagach is close to the oblast center (about 40 km), but it has enough demand to support its local market, in contrast with Baizak.

Since we do not have much data on livestock production, demand, and interregional flows of animals in this region, to simulate the model we occasionally used alternative information or simply guessed the relevant figures.[11] Table 2 lists the data used in the model.

First, we used the total stock of sheep and goats as the supply level of lambs. Since we have such figures only at the oblast level, we guessed the supply at each location. In this paper, we assume a fixed supply, because we do not know price elasticity of livestock supply. However, this assumption is not unreasonable, because supply does not seem to be elastic. In a field survey taken in summer 1999 by the author, most farmers answered that they sell their animals when they need cash rather than in response to price movements.

Per capita, the population of "lambs" is larger in Dzhambul Oblast. Thus we treat Dzhambul Oblast as the exporting region and Southern-Kazakhstan Oblast as the importing region. We also guessed the equilibrium quantity in each market. At the initial equilibrium, we set the per capita consumption of lambs equal in both oblasts. Equilibrium prices are taken from the survey data and TACIS data.

While the supply is fixed, demand for lambs is considered to be more flexible. To obtain a linear (inverse) demand curve ($P = A - B*Q$) at each market point, we used a fixed price elasticity of demand ($\varepsilon$). Thus for each location $B = P/(Q*\varepsilon)$ and $A = P + B*Q$. The initial equilibrium figures in Table 2 are used for P and Q. Since there is no estimate of demand elasticity for Kazakhstan, we used $\varepsilon = 0.6$, which was estimated by Yamamura (1999) for Russian consumption of meat and meat products.

The distances between the market points are measured using maps, and they are shown in Figure 1. For the "rest of the oblast" (R1 and R2) the distances are chosen so that the model calibrates to the initial equilibrium price and quantity.[12]

The transport cost per km per head is calculated from the data taken in the field survey. Although the transport cost depends largely on whether the farmer has a truck or not, for simplicity we take the average. The estimated transport cost is 8 tenge[13] per km per head.

---

[11] Some of the data problem will be resolved in the elaboration of this model.

[12] Unfortunately, however, the calibration failed. This point may be improved with better data.

[13] In September 1999, the exchange rate was US$1 = 132 tenge. Gasoline costs 20 – 30 tenge per liter.

The spatial equilibrium model is solved by GAMS by maximizing the total welfare in the region (consumers' surplus plus producers' revenue minus transport costs). With spatial integration and competitive markets, the result should be identical to the result of arbitrage behavior of individual farmers (i.e., competitive equilibrium).

Although calibration of price and quantity failed, we obtained the trade in desired directions. The trade flows in the base model is shown in Figure 2 by arrows. The only inter-oblast trade is done through market R1. Zhanatas and Uzunagach do not trade with any other markets.

## Simulations

With the base model described in the previous section as the starting point, we implement three simulation exercises.

### Investment in transportation system

As mentioned earlier, the transportation system in Kazakhstan has been deteriorating since independence, although road and railroad networks are relatively well established throughout the country and to other countries. Cracks are found everywhere on roads, the vehicles are remnants of the Soviet era, and gasoline is very expensive relative to other commodities. Individual farmers may not be significantly affected by transportation problems, because they face other acute problems, but in the aggregate the welfare loss to the poor transportation infrastructure may be quite large. To measure this welfare loss, we implement a simulation of reduction in transport cost. Lower transport costs can be achieved many different ways. For example, the government could invest in road repair, auto parts could be produced rather than importing them from the Ukraine, and gasoline could be produced rather than exporting raw oil and importing gasoline from Russia. We call this exercise investment in road quality.

The simulation is done by gradually reducing the transport cost from the current level at 8 tenge per km per head. The change in social surplus (welfare gain) is plotted in Figure 3. From the graph we can see that the benefit of better road increases at an increasing rate. The magnitude also is not negligible. According to the model calculation, reducing the transport cost by 20% (from 8 to 6.4 tenge per km per head) will raise the total welfare in this region by 37 million tenge or 280,000 dollars. Since we utilized the figure of total stock of sheep and goats for the stock of lambs, the model overestimates the welfare impact of better roads on the lamb sector. Nevertheless, it almost certainly underestimate the total welfare increase in the region because sectors other than lambs will also benefit from better roads.

### Reintroduction of trains for animal transport

The next simulation is similar to the previous one except that the reduction in the transport cost occurs only in the railway routes. During the Soviet era, trains were extensively used to move animals between farms and pastures and from farms to the markets. Since independence, trains have not been used for animal transport. People are allowed to use trains only as passengers. Therefore, since railroads are established fairly extensively in this region, bringing trains back as a means of animal transport may improve welfare. Figure 1, the dashed lines represent railroads.

Since not all routes are subject to lower transport costs, the increase in the social surplus is smaller than in the previous simulation. Still, we find an increasing marginal effect of lowering transport cost in this case (see Figure 4). A 20% cut in the transport cost by train relative to the conventional road transport will increase the welfare in this region by 4.7 million tenge or 36,000 dollars.

This exercise did not predict a large increase in the social surplus so that such investment may not actually be supported. This is probably due to our model specification that the two largest "markets" R1 and R2 are not connected with other markets by railroad. In reality, however, at least some of the raions aggregated into R1 and R2 are located on the railroad routes. If that is the case, the current result underestimates the welfare effect of the reintroduction of railway as a means of animal transport.

### Supply shock

The final exercise involves examination of the sensitivity of prices to external shocks in this region, e.g., bad weather, epidemics among animals, or changes of taste amongst consumers. One of the issues regarding spatial integration of markets is the effect of integration in reducing fluctuations of prices and quantities over time and across regions. When some negative shock occurs, the better connected are the markets, the less vulnerable the society should be, because with better connection people in higher need can get what they want.

In this exercise we introduce a negative shock to this region by cutting the supply level in Shimkent by 30%. We then compare the trade patterns and price increases across markets and across three different settings of the transport system: (1) the base model, which is the current situation; (2) better roads (the first simulation with transport cost of 4 tenge per km per head); and (3) the reintroduction of trains (the second simulation with transport cost of 4 tenge for train routes and 8 tenge for road routes).

One of the largest changes after the shock is that the self-sufficient markets come into the regional trade to meet the deficit of this region. Uzunagach starts exporting to Shimkent and Zhanatas sends its livestock to Karatau.[14] In reality, this happens when individual farmers detect a rise in the animal price in nearby markets and when the rise in price is sufficient for them to cover the cost of shipping their animals to other places. For this arbitrage by individual farmers, the transportation system or the transportation cost matters. Since Uzunagach is close and well connected to Shimkent by road and railroad, Uzunagach's participation in regional trade is found in each transportation scenario after the shock. On the other hand, remote Zhanatas enters the trade network only when the transport cost is lower, which occurs in both scenarios (2) and (3), as it is on the rail lines.

---

[14] Our model predicts that even without the supply shock in Shimkent, these two markets enter the regional trade under scenario (3).

Price increases in each market are listed in Table 3. Taraz and Karatau on railway routes face the smallest effect of the shock under the train scenario (column (3)). Along the railway network, after the shock exports increase from Karatau to Taraz and Zhanatas to Karatau.

As new exporters, both Uzunagach and Zhanatas face declines in local consumption. Since Uzunagach is located on a train route, it exports to Shimkent, and hence the price increase in Uzunagach is largest under the train scenario. Because Zhanatas has already begun exporting to Karatau under the train scenario before the shock, the effect is smaller under the train scenario than the road scenario, even though it is on a train route. Two major supply sources to Shimkent are R1 and R2. Facing the supply shock, their burden is large, but smallest when roads are better (column (2)).

With these complicated trade diversions by other participants in the regional trade, Shimkent, the source of the shock, faces a rather moderate price increase after the shock. Moreover, the effects of the supply deficit do not differ much under different transportation settings. This may be because Shimkent is already well connected with other markets. Even though Shimkent is evenly well rescued from the supply shock, the region as a whole suffers from it differently under different transportation scenarios. With a good road network, the decline in the total welfare of this region is lowest (-3.19%). The welfare loss of the train scenario is almost the same as that of the present situation (-3.40% vs. –3.43%).

## Conclusion

After these simulation exercises, we find that the regional trade works rather well even under the current transportation network. When a shock occurs in Shimkent, price information is transmitted over to Taraz through the arbitrage behavior of farmers at the intermediate markets. This result of the simulations is consistent with the findings from the statistical tests of market integration in section II. However, it is also true that there are remote markets like Zhanatas that are not affected by shocks to external markets, simply because they are not well connected to the outside world. In present situation scenario, Zhanatas was not affected at all by the supply shock in Shimkent under the current transport setting.

The simulation exercises tell us that investment in the transportation system is favorable to the livestock sector in this region. First, it will improve both producers' and consumers' welfare in this region by facilitating the deliveries of products to consumers who have a higher willingness to pay. Second, under a better transport system, the effect of supply deficits in particular markets is spread out more extensively, so that a severe consumption crisis in the deficit area can be avoided.

The figures for welfare gains may not sufficiently large to actually support such investment in transportation system. For example, investment in projects that would make decrease the cost of public transportation from Baizak Raion to Taraz from 160 tenge to 120 tenge for one lamb throughout the region would bring about a welfare increase of 350,000 dollars, according to the model calculation.

However, larger welfare gains from investment in transportation may be possible if we consider other aspects of the livestock sector in Kazakhstan. First, we fix the supply at each location in our spatial equilibrium model, but the supply can be flexible. If supply is flexible, a better transport system may pull out additional production that is not currently realized because of the poor marketing infrastructure. As stated earlier, we got the impression from the livestock farmers we met in the field survey in Southern Kazakhstan that their production and marketing behavior is highly inflexible. They face various kinds of constraints in production activity such as land rights, credit availability, machinery, and technical and managerial knowledge and skills. Such a constrained environment forces them to do their business with what they happen to have currently, leaving them not much flexibility regarding the number of animals to raise and sell.

Under such a circumstance we consider the price elasticity of supply of livestock in this region is extremely low, if not zero, and as a result the welfare effect of investment in transportation may be limited. Land reforms and introduction of new technology through agricultural extension works may improve the flexibility of production and supply of livestock and livestock products in this region.

Another issue we did not treat in the spatial equilibrium model in this paper is the possibility of export. Throughout Soviet history, Kazakhstan was a major producer of livestock products in the Soviet Union. Ties with the rest of the FSU have weakened, and Kazakhstan's exports to FSU countries have decreased dramatically. Kazakhstan may hope to reestablish the link with the FSU countries and start exporting livestock products to them.

However, the prospect may not be bright with the current income levels in other FSU countries and the production structure in Kazakhstan. Yamamura (1999) projects Russian consumption demand for meat and meat products over the next ten years. He states that even with fast growth in real income (2 – 3%), Russian consumption will not reach the level of the Soviet period. But he also states that larger demand in Russia is possible if import prices drop. Therefore, in order for Kazakhstan to expand the marketing channel of its livestock products to other countries, or at least to Russia, the livestock sector needs to improve efficiency and lower the costs of production.

These considerations call for studies on microeconomics of livestock farmers in Kazakhstan. For policy making for reconstruction and development of the livestock sector in this new market-based economy, it seems imperative to understand the nature and the extent of economic and technical constraints that farmers face and to foresee how their behavior will change if such constraints are removed.

## References

Baulch, B. (1997a). "Transfer Costs, Spatial Arbitrage, and Testing for Food Market Integration." American Journal of Agricultural Economics **79**(2): 477-87.

Baulch, B. (1997b). "Testing for Food Market Integration Revisited." Journal of Development Studies **33**(4): 512-34.

Berkowitz, D., D. DeJong and S. Husted (1996). Transition in Russia.

Blanchard, O. and M. Kremer (1997). "Disorganization." Quarterly Journal of Economics **112**(4): 1091-1126.

EU/TACIS – KIMA Agency (1998-1999). Weekly Bulletin of Livestock Prices. Almaty, Kazakhstan, EU/TACIS Agricultural Information on Markets Project - KIMA Agency.

Martin, L. J. (1981). "Quadratic Single and Multi-Commodity Models of Spatial Equilibrium: A Simplified Exposition." Canadian Journal of Agricultural Economics **29**(1): 21-48.

McNew, K. and P. L. Fackler (1997). "Testing Market Equilibrium: Is Cointegration Informative?" Journal of Agricultural and Resource Economics **22**(2): 191-207.

Mwanaumo, A., W. A. Masters and P. V. Preckel (1997). "A Spatial Analysis of Maize Marketing Policy Reforms in Zambia." American Journal of Agricultural Economics **79**(2): 514-23.

Rozelle, S., A. Park, J. Huang and H. Jin (1997). "Liberalization and Rural Market Integration in China." American Journal of Agricultural Economics **79**(2): 635-642.

Wan, G. (1997). Rice Market Integration in China.

World Bank (1996). Transport Sector Review: Introduction and Executive Summary. http://www.worldbank.kz/content/esw4_eng.html, World Bank.

Yamamura, R. (1999). Surabu Kenkyu (Slav Study).

Yao, S. and D. R. Colman (1990). "The Effects of Agricultural Policies on the Patterns of Specialized Grain Production in China: an Application of a Quadratic Spatial Equilibrium Model in the Chinese Grain Sector." Oxford Agrarian Studies **18**(2): 81-95.

Figure 1-A.  Price Movement for Small Animals

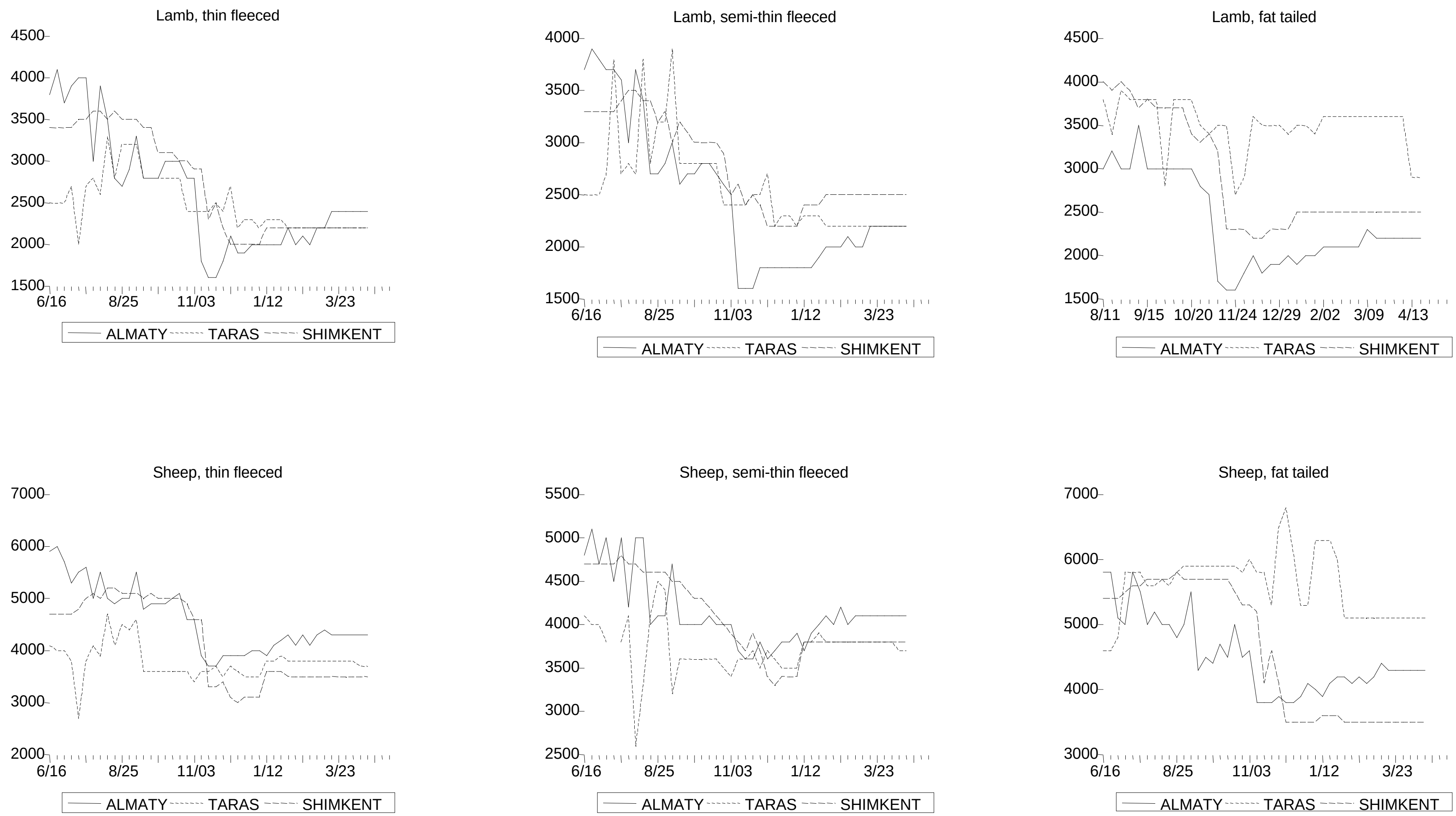

Figure 1-B.  Price Movement for Large Animals

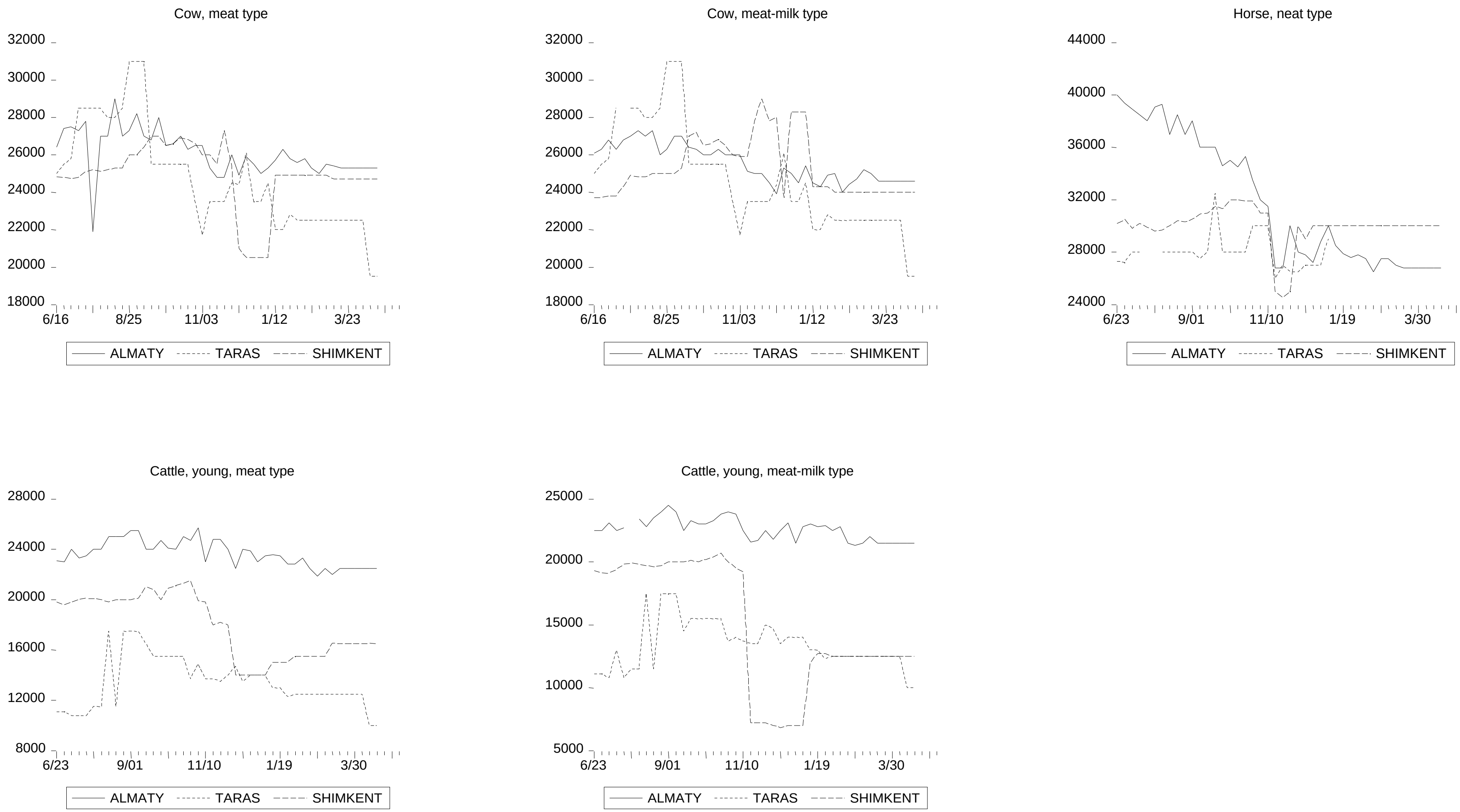

Figure 2. Two-Oblast Model

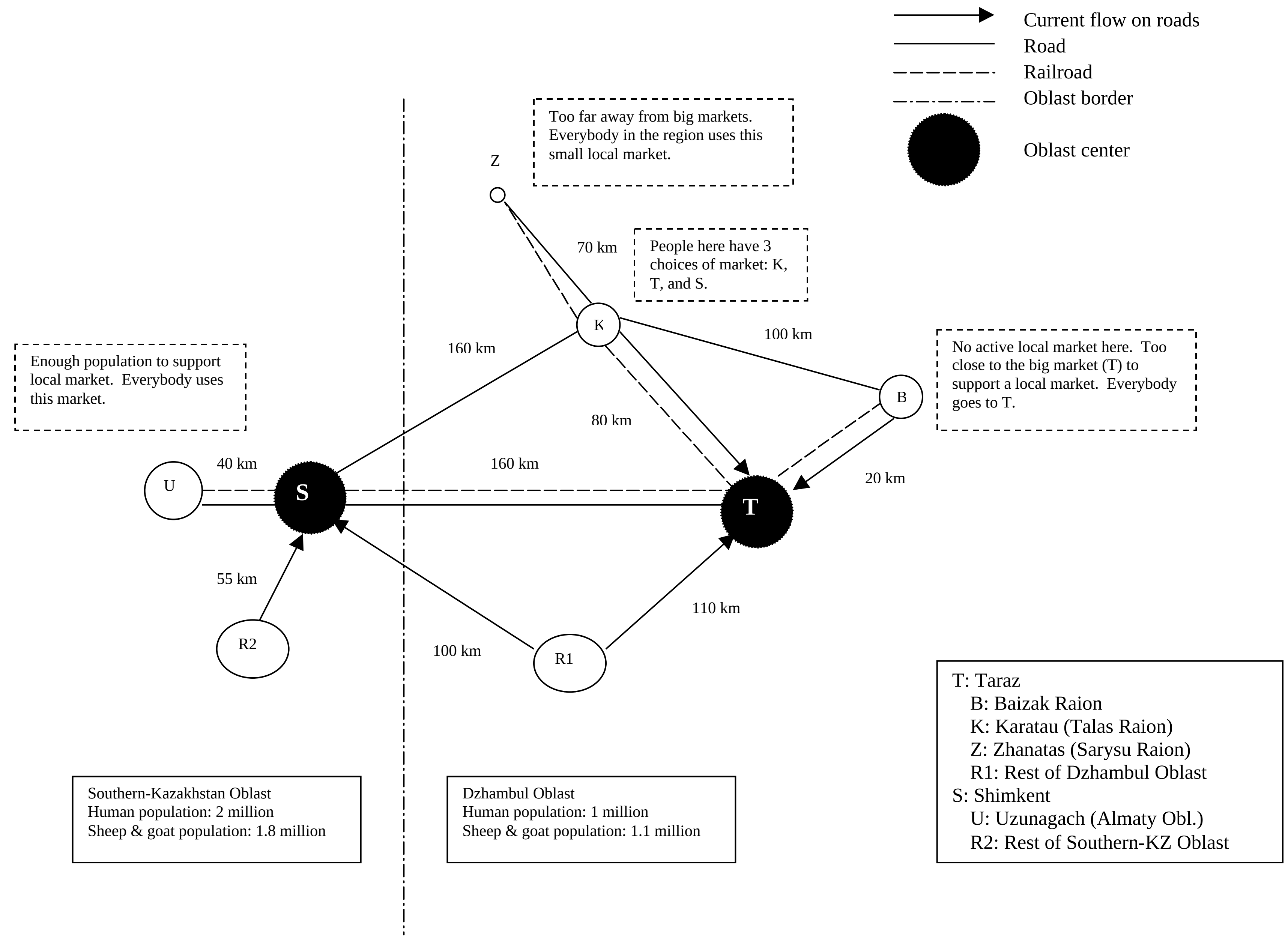

Figure 3.  Welfare Effect of Investment in Road Quality

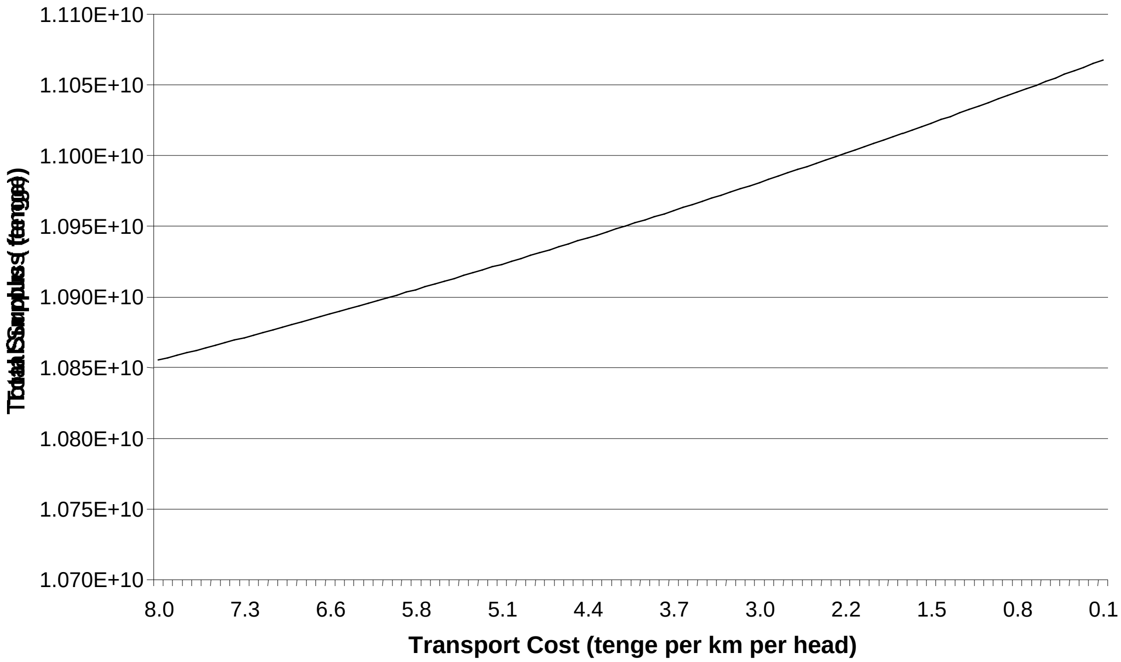


Figure 4.  Welfare Effect of Investment in Railroad

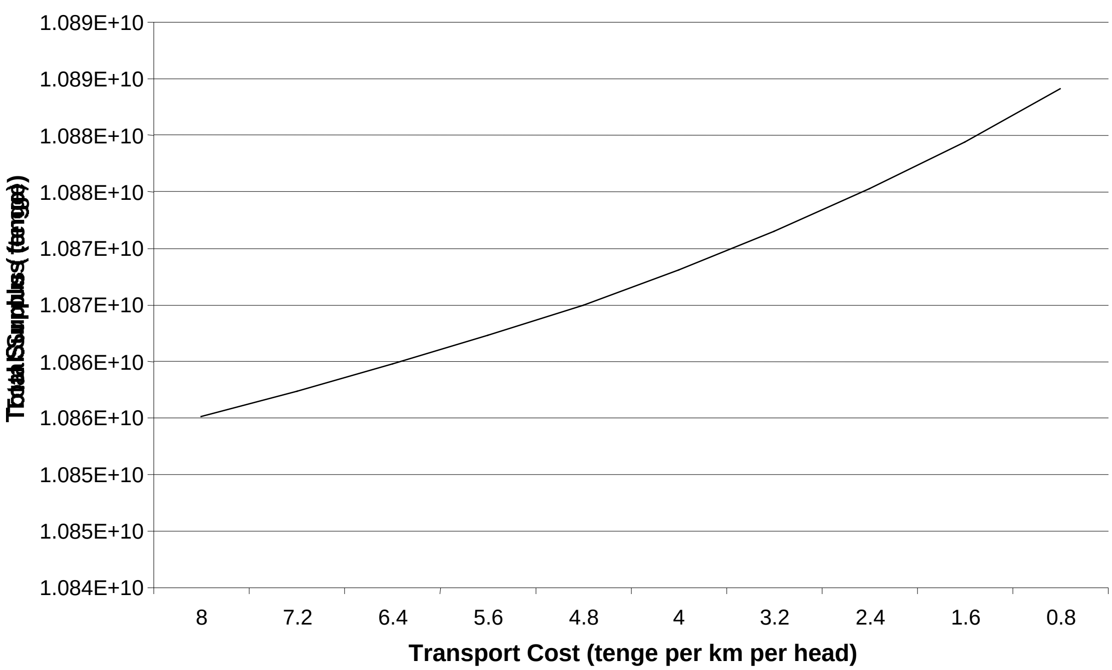

Figure 3. Welfare Effect of Investment in Road Quality

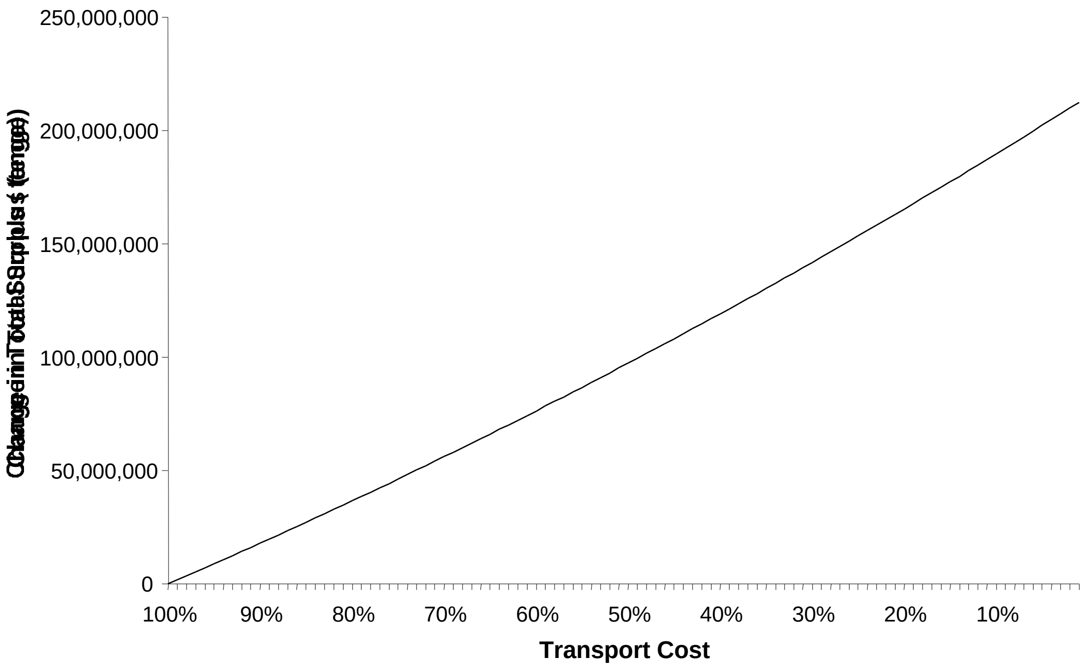


Figure 4. Welfare Effect of Investment in Railroad